Distr.
LIMITED

E/ECA/NRD/FRCDUMRA/5
15 February, 1991

Original: ENGLISH

UNITED NATIONS
ECONOMIC AND SOCIAL COUNCIL

UNITED NATIONS
ECONOMIC COMMISSION FOR AFRICA

Fourth Regional Conference on the
Development and Utilization of
Mineral Resources in Africa

Ouagadougou (Burkina Faso)
18-27 March 1991

MINERAL RESOURCES DEVELOPMENT AND THE ENVIRONMENT IN AFRICA

TABLE OF CONTENTS

	Paragraphs	Page
PREFACE		(ii)
INTRODUCTION	1 - 5	1
THE ROLE OF MINERALS IN DEVELOPMENT	6 - 15	2 - 3
Introduction	6	2
The fuel minerals	7 - 9	2
The metals	10 - 12	2 - 3
The industrial minerals	13 - 15	3
ENVIRONMENTAL FACTORS AFFECTING MINERAL RESOURCES DEVELOPMENT	16 - 19	3 - 4
ENVIRONMENTAL CONCERNS REGARDING MINERAL RESOURCES DEVELOPMENT	20 - 48	4 - 9
Introduction	20 - 26	4 - 5
The African situation	27	5
Man-made environmental constraints inhibiting mineral development	28 - 32	5 - 6
Current environmental concerns associated with mineral development in Africa	33	6
Large to medium-scale mining	34 - 37	6 - 7
Small-scale mining	38	7
Uranium mining	39 - 44	7 - 8
Asbestos production	45 - 48	8 - 9
MEASURES FOR MINIMIZING ADVERSE ENVIRONMENTAL IMPACTS RESULTING FROM MINERAL RESOURCES DEVELOPMENT	49 - 80	9 - 14
Introduction	49 - 50	9
The United States (USA) experience	51 - 59	9 - 10
The Ghana experience	60 - 67	10 - 11
The experience of mineral development industries	68	11 - 12
The energy minerals	69	12
Metals - the Canadian experience	70 - 74	12 - 13
Industrial minerals - the European Community (EEC) experience	75 - 80	13 - 14

GENERAL ENVIRONMENTAL CONSIDERATIONS FOR NEW MINERAL DEVELOPMENT PROJECTS . . . . . 81 - 85 14

CONCLUSIONS AND RECOMMENDATIONS REGARDING ENVIRONMENTAL ASPECTS OF MINERAL RESOURCES DEVELOPMENT IN AFRICA . . . . . 86 - 96 15 - 16

REFERENCES . . . . . 17 - 18

PREFACE

The conservation and protection of the environment in the process of development has in recent years become a subject of great concern especially in the industrialized countries. Many of these environmental concerns are associated with the extraction, processing, smelting, refining and utilization of mineral-based products. For example, extraction of minerals disturbs the ecosystem; processing of some minerals results in large tonnages of mineral waste which could release harmful substances to the environment; smelting and refining of metals releases gaseous pollutants to the atmosphere; and the discarding of used mineral based products can disturb the environment both physically and chemically.

Within developing Africa, information regarding measures taken to conserve and protect the environment in the process of mineral resources development is very scant. The objectives of this paper are therefore to (a) stimulate environmental awareness in mineral resources development in the region; (b) promote the acquisition of knowledge by African countries about policies and activities related to the environment and mineral resources development, and (c) facilitate the evolution of environmentally acceptable standards for the development of mineral resource in the African region.

The Secretariat of the United Nations Economic commission for Africa will highly appreciate receiving information from African governments, mining and other mineral related industries, research institutions, among others, on their experience on mineral development and the environmental protection. Such information will be used at a future date for the preparation of an Africa-wide study on mineral development and environmental protection for use by all interested parties in the African region.

INTRODUCTION

1. Minerals embrace all non-living substances extracted from the earth for use by man. Generally, these economic minerals include the energy fuels (coal, oil, natural gas and uranium); metals; and non-metals (or industrial minerals),[1] classified on the basis of their uses and their physical and chemical characteristics.

2. On the other hand, environment is used to describe the total setting for economic development activity. The term refers not only to the naturally occurring milieu (the ecological systems which surround and collectively support man), but also extends to the socio-cultural milieu which man has created to adapt to the demands and challenges of his naturally occurring surroundings. Ecology is used to refer to the relationship between organisms and their environment, including most especially the man-environment relationship.[2]

3. Mineral resources development covers all activities by man involved in the search for, production and eventual use of mineral-based products for the enhancement his living standard. The development of mineral resources results in both positive and negative impacts to the environment. Hence, there are interrelationships between natural resources (including minerals), population, development and the environment.[3]

4. The developing countries of Africa are concerned with two different types of environment problems in the mineral resources development sector: in the first type the countries have to alleviate poverty through the development of their mineral resources, while in the other, they have to seek ways to prevent the environmental deterioration often associated with mineral development.

5. It should further be noted that the presence of widespread poverty in the African continent is often a cause of serious environmental deterioration in the region. The rural poor, for example, use firewood as an energy source for sheer survival, in ways which are unsustainable over the long-term. Thus, many of Africa's most severe environmental problems are in part a direct consequence of extreme poverty, and it is neither likely nor realistic to expect that impoverished people living at the margin of existence will consider the long-term sustainability of the planet at the cost of their own survival. Only concerted worldwide attack on socio-economic roots of extreme poverty, one that provides people with the opportunity to earn a decent livelihood in a non-destructive manner, will permit protection of the world's natural systems. Nor will development and economic reforms have lasting success unless they are suffused with concern for ecological stability and wise management of resources.

THE ROLE OF MINERALS IN DEVELOPMENT

Introduction

6. The fuel minerals contribute over 80 percent of the world's commercial energy. The metals and industrial minerals are essential for the development of infrastructure to produce the goods and services required by man. Yet developing Africa consumes an insignificant proportion of the world's production of mineral resources. This situation, in part, explains the extreme poverty that exists in the African region. It is expected that in order to improve the living conditions of the African people, increased production and consumption of minerals will have to be effected in the coming years.

The fuel minerals

7. It is estimated that in 1989 the total world energy use amounted to 9300 million tons of oil equivalent (mtoe).[4] The percentage contribution of this energy by source was as follows: oil 33.3%; coal 24.0%; natural gas 18.4%; renewables (hydropower, solar, hydrothermal, etc.,) 19.5%; and the nuclear 4.8%. Thus the fuel minerals (oil, coal, natural gas and uranium) contributed 80.5% of the world's energy during the year.

8. Developing Africa's share of 1988 world commercial energy consumption of 7009 mtoe is estimated to have been of the order of 101 mtoe or 1.4% of the world total.[5] Hence commercial energy consumption in the developing countries of Africa is very low indeed. The estimated contribution of the commercial energy consumed in developing Africa by source was as follows: liquids (oil) - 62 mtoe or 61.4%; solids (coals) - 7 mtoe or 6.9%; gas (natural gas) - 28 mtoe or 27.7%; and electricity - 4 mtoe or 4.0%. Even with this relatively little commercial energy consumed in developing Africa, 96.0% is estimated to have originated from fuels minerals, excepting uranium.

9. Commercial energy is consumed in such basic industries as agriculture, manufacturing, transportation, heating, lighting etc, for the production of the goods and services used by man in every day life. However, the high dependence of modern life upon energy from fuel minerals which are non-renewable and finite, raises serious environmental problems which will be considered in other sections of this paper.

The metals

10. Metals are widely used in various sectors of the world economy including the manufacture of agricultural and industrial machinery and equipment; the production of transport equipment (automobiles, aeroplanes, ships, motorcycles, etc); the construction of physical infrastructure (residential and commercial buildings, bridges, railway track, etc); the generation and transmission of electric energy; the transportation of oil, gas and water; and the production of various household goods such as cookers and refrigerators.

11. With the notable exceptions of metals such as iron and aluminium, metals generally occur in combination with a large proportion of other unwanted minerals from which they must be separated, creating enormous amounts of waste to the environment. Metals are thus relatively high priced and together with the fuels minerals, they are internationally traded commodities.

12. Steel (alloyed iron), aluminium and copper are the most consumed metals in the world in terms of tonnages involved. World production of these metals (crude steel, primary aluminium and refined copper) during 1988 amounted to 778.1, 17.5 and 10.7 million metric tons respectively. The contribution of developing Africa towards this production was of the order of 0.6% crude steel, 2.4% primary aluminium and 7.1% refined copper. Consumption of the three metals by developing Africa is estimated to have been of the order of 0.5% steel, 0.7% primary aluminium and 0.3% of refined copper.[6]

The industrial minerals

13. With some exceptions such as the fertilizer minerals, diamonds and asbestos, the industrial minerals generally occur in abundance throughout the earth and find widespread use in construction, the chemical industries and several other industrial areas. The group includes such building materials as sand, rock, limestone, gypsum and clay; the fertilizer minerals of sulphur, potash and phosphates; and such diverse minerals as salt and diamonds.

14. Many of the industrial minerals are used in much the same from in which they are mined and require relatively little processing. Such minerals like the construction materials are low-priced and produced mainly for local consumption. Those industrial minerals which do not occur in great abundance or require detailed processing normally command relatively high prices and are traded internationally. The fertilizer minerals, diamonds and asbestos are examples of such industrial minerals.

15. Worldwide, the tonnages of industrial minerals consumption (in particular the construction materials) far exceeds the tonnages of metals consumed. Hence a high intensity use of industrial minerals in an economy reflects the strength of construction and other related industries. Though difficult to estimate quantities of industrial minerals consumed in developing Africa, the poor state of physical infrastructure (houses, roads etc) and agricultural development in the region are among the factors which indicate that the consumption of these minerals is similarly low compared to other world regions.

ENVIRONMENTAL FACTORS AFFECTING MINERAL RESOURCES DEVELOPMENT

16. The geological environment determines the geographic distribution of economic minerals worldwide. Hence most mineral exploration programmes begin with the assessment of a country's geological attractiveness for target mineral commodities. The production of minerals is, however, enhanced by such other environments as, in decreasing order of importance, political stability; attractive mineral development policies; technological and financial capability;

the availability of physical infrastructure and utilities; and the geographic location of a mineral deposit relative to the consumers of the useful minerals to be produced.[7]

17. The environmental factors influencing mineral resources development as outlined above are not static. For example, some geologically favorable areas could have some economic minerals which remain to be discovered. Improvements in political, technological, economic and other variables could result in increased mineral production in some areas. Conversely, the deterioration of political conditions could adversely affect mineral production in already established producing areas.

18. Because economic mineral resources are unevenly distributed among countries, and minerals are essential and dominant in industrialization , the desire to acquire mineral resources has over time been the cause of many wars among people and nations with grave environmental consequences. International policy and diplomacy often times have centered on areas of strategic mineral wealth. Hence the world supply of mineral commodities (the fuel minerals, metals and some of the industrial minerals) is such that there is and probably will be a high degree of interdependence among nations.

19. Developing Africa as a unit possesses a vast variety of mineral resources. However, these minerals remain underdeveloped due to social, economic and technological constraints which have prevented many of the countries from transforming these resources to products which could be used internally for the advancement of living conditions of the majority of their people. Hence it is imperative for the countries of the African region to create the necessary political, economic and technological environment to enhance the discovery and development of the mineral resources of the region to meet the needs of the people.

ENVIRONMENTAL CONCERNS REGARDING MINERAL RESOURCES DEVELOPMENT

Introduction

20. Environmental concerns and policies affecting mineral development and utilization are a subset of political factors with local, regional and global dimensions. These concerns and policies arise because of the effects which mineral resources development causes on the environment and, inversely, the effects that environmental issues may have upon the way in which mineral development is undertaken.[8]

21. It should be noted that environmental problems caused by mineral resources development differ in the amount of time they take to become realizable. Furthermore, they differ in severity and reversibility in each of the three categories.

22. Local environmental problems caused by mineral resources development are confined within the boundaries of a particular country. Examples include: the disturbance of landscape; the release of gaseous, liquid and solid effluents to

surrounding areas causing threats to human and ecological health; and health hazards for workers in mineral related industries.

23. Conversely, at the local level environmental concerns may prevent the development of an otherwise economic mineral resource because of land use conflicts. This situation could arise in such situations as national parks where wildlife could be distributed, and in heavily populated centres where property values could be undermined.

24. Additionally, at the local level political, economic, technological and other constraints may prevent the development of mineral resources to meet the basic needs of the people and thus contribute towards worsening their living conditions. Civil strife, disincentives to private investment, lack of investment resources and poor leadership are among such factors which constrain mineral resources development, leading to environmental degradation of the people who would otherwise have benefitted from their exploitation.

25. Regional environmental problems caused by mineral resources development result from biophysical linkages among a group of countries but have little effect beyond the members of the group. A typical example is the effect of river water pollution resulting from mineral development activities in respect of downstream countries where the polluted waters pass. These polluted waters could adversely affect the ecosystems of the countries so contaminated.

26. At the global level, environmental problems caused by mineral development influence the composition of the biosphere and thus affect nearly all countries. For example, the burning of fossil fuels for energy generation increases the carbon dioxide and sulphur dioxide levels of the atmosphere. Similarly some metallurgical processes release the same gaseous effluents to the atmosphere. The combined effects of these gaseous effluents together with other gaseous effluents from other sources contribute towards the problems of acid rain, ozone and the greenhouse effect which have in recent years become international environmental issues of great concern.

The African situation

27. At the present state of mineral resources development in developing Africa, there are a number of environmental concerns associated with mineral resources development at the local and regional levels. These include man-made constraints inhibiting mineral development responsive to the needs of the region, and adverse environmental effects resulting from mineral development at the mining, processing, smelting and refining levels.

Man-made environmental constraints inhibiting mineral development

28. Civil strife in countries such as Angola, Liberia and Mozambique has constrained mineral development and contributed towards the deterioration of living conditions of the citizens of the affected countries and the destruction of physical infrastructure.

29. In several African countries the policies adopted for the development of their mineral resources especially during the late 1960s and the 1970s drove away private initiative (both foreign and local) in the sector of mineral resources development and accordingly deprived their citizens from potential economic benefits arising from mineral exploitation.

30. Lack of political will at the country levels for bilateral, subregional and regional cooperation in development through the pooling of investment resources, the use of complementary natural resources to establish mineral based and other industries and the creation of large internal markets for mineral based products has slowed the production and consumption of minerals in the continent hence depriving the people of the continent of essential necessities.

31. Much of the current production of minerals in the African region is exported with relatively little processing. Accordingly, the value of mineral exports is diminished because of limited value added; African industrialization based on domestic mineral production is constrained; and the stimulation of other economic activities in the continent based on domestic mineral production (such as physical infrastructure development, employment generation, skills acquisition etc.,) are limited. The fact that African mineral endowment does not fully respond towards economic activities intended to improve the living standards of the African people contributes to the extreme poverty pertaining in and environmental deterioration of the continent.

32. A variety of positive economic side-effects resulting from mineral resources development in the continent could be realized if the mineral industries of the region were oriented to meet the basic needs of the people. This will require cooperation by the countries and investors so that the linkage from mining of ore through smelting and refining to fabrication of metal products and finally to capital goods production can be realized.[9]

Current environmental concerns associated with mineral development in Africa.

33. In examining the current adverse impacts of mineral resources development in Africa, existing large to medium scale mining operations and small scale mining will be covered. In addition, the special cases of uranium mining and asbestos production which are best known for health hazards will be reviewed.

Large to medium-scale mining

34. Surface mining involves the movement of enormous quantities of soil and rock (overburden) to reach the ore. Such mining regularly obliterates whatever ecosystems sit atop ore deposits. Some surface or underground mining wastes such as asbestos and uranium constitute health hazards. Other mining wastes bearing some ore can contain acid-forming chemicals, heavy metals such as lead and cadmium, and other environmental contaminants, which water and wind can carry far beyond the mine. Mining can cloud the air with dust, create noise and pollute water systems. Production and transportation of oil can damage fragile environments through oil spills.

35. After surface or underground mining of ores, the process of concentrating them leaves large tonnages of residues (tailings). Finally, in metal production, smelting and refining remove remaining impurities (slag) which also require disposal. Smelting and refining release large amounts of air pollutants, the composition of which depends on the metal being produced. Sulphur oxides, arsenic, lead and other heavy metals are among the pollutants commonly produced by smelters. Petroleum refining similarly contributes to air pollution. Added together, over time, these polluting effects can cause considerable environmental damage to communities and ecosystems especially in mineral development sites.

36. Although the most visible and immediate impacts of mineral production are local, there are regional and global effects as well. Mineral industries that produce bulk materials (such as petroleum, glass, cement and clay products, industrial chemicals and metals) are about ten times as energy-intensive as other manufactures. This high level of energy use makes the production of minerals an appreciable contributor to acid rain and global warming (resulting from carbon dioxide additions to the biosphere).

37. Many of the existing African mineral industries are relatively old (relative to current environmental awareness) and therefore may not be operating at safe environmental standards. Published information regarding their adverse impacts on the environment is scant. It might thus be advisable for some of the existing mineral resources industries of the region and the host governments to institute measures to bring these industries to currently acceptable environmental operating conditions. Likewise, new mineral development projects in the region have to incorporate the most up to date environmental conservation and protection measures in order to bring the African industry to world acceptable environmental standards.

Small-scale mining

38. Small-scale mining of such minerals as gold, diamonds and other precious minerals, building materials etc., in several African countries is contributing to the deterioration of physical environment through inappropriate and wasteful working practices, and non-rehabilitation of exploited areas. Similarly there are social environmental problems associated with these operations resulting from lack of support infrastructure for those working in the industry. The development of workable small-scale mining policies; the provision of training and technical assistance to small-scale mineral development operators; the provision of required physical infrastructure etc., by government institutions are some of the areas of improvement in this sector.

Uranium mining [10]

39. Uranium is currently mined in several countries of the world including Gabon, Namibia and Niger within developing Africa. Environmental concerns on uranium mining and utilization arise in three main phases: in uranium mining and processing; in operating nuclear power stations; and in waste disposal from power stations.

40. Uranium mining involves risks to health at all stages. In the mines, the radioactive ore produces a derivative called radon, a radioactive gas which in turn produces intensely radioactive derivative products. Inhalation of these radioactive gaseous products could cause lung cancer. Thus uranium miners could be susceptible to lung cancer as a result of occupational radiation exposure.

41. After mining the material is crushed and milled to the constituency of fine sand. Chemical treatment then produces a substance called "yellowcake" which contains about 85% uranium. The yellowcake is accompanied by about one hundred times its weight of residual sand which is discarded near the mining site.

42. The uranium tailings (the discarded waste from processing) represent a more widespread threat to human health. These wastes remain radioactive for many years and exposure of human beings to the gaseous radioactive derivatives from these tailings in the disposal sites, or other areas where wind could have carried them, could cause lung cancer to people for many years to come.

43. With regard to electricity generation from uranium, many people consider this energy source environmentally destructive, dangerous and expensive. Some 15% of the world's electricity is now produced from nuclear origins, although nine-tenths of this is the result of only ten countries' operations. Around the world, the pace of nuclear energy development has slowed in recent years partly because of the threat of large-scale environmental destruction resulting from possible accident in nuclear power stations. No country in developing Africa produces energy from uranium.

44. At present, no long-term solution for waste disposal from nuclear power stations has been developed. This waste exists in various forms--gas, liquid and solid--and with strengths ranging from mildly to extremely radioactive. Countries in developing Africa should at all cost avoid the importation of such waste for disposal in their countries to avoid environmental degradation in the region.

Asbestos Production [10]

45. Asbestos is a mineral rock mined in several countries of the world including, in developing Africa, Namibia, Swaziland and Zimbabwe. The mineral can be divided into very fine fibres which are technically strong and resistant to heat and chemical attack. These fibres are subsequently used in common applications in households, industrial premises, and public buildings. The mineral is for example, used in cookers and refrigerators; boilers, storage heaters and radiators; and in insulating boards and asbestos cement.

46. The environmental danger from asbestos is to be found in the fibres which if inhaled for some time could result in three main asbestos related diseases. These diseases are asbestosis, lung cancer and mesothelioma. Asbestosis is an irreversible, often fatal scarring of the lungs, that usually occurs only after heavy exposure to asbestos. Mesothelioma is a cancer of the inner lining of the

chest or abdominal wall. All the three diseases take a long time to develop, usually ten to twenty years, though this may be up to 40 years in the case of cancer.

47. Generally, asbestos products are considered to be safe in everyday use, provided that they are not broken open, drilled or allowed to deteriorate in such a way that fibres are released. However, most uses of asbestos are now banned or being phased out in several countries and asbestos is increasingly being substituted with other materials in many applications.

48. Of particular environmental care in African producers of asbestos is asbestos mine waste which could release asbestos fibres to the environment. Rehabilitation of asbestos mining areas would thus be necessary in order to avoid environmental problems caused by asbestos as outlined above.

MEASURES FOR MINIMIZING ADVERSE ENVIRONMENTAL IMPACTS RESULTING FROM MINERAL RESOURCES DEVELOPMENT.

Introduction

49. Because of general public concern on environmental problems caused by mineral resources development, actions have in recent years been initiated at various levels in the mineral industries and at government levels in several of the developed countries of the world.

50. With regard to local and regional environmental problems caused by mineral resources development the United States of America and Australia are reported to be among the leaders in the development and implementation of environmental regulations in the mineral industries. It is believed that the regulatory history and experience of these countries could represent at least a direction likely to be followed more or less universally.

The United States (USA) experience [11]

51. It is reported that until well into the twentieth century, the United States of America's mining industry, along with much of the country's industrial sector, was largely unregulated (on matters of the environment). It was the increasing awareness of, and concern for, the environment which was largely responsible for the passage of the National Environmental Protection Act (NEPA) by Congress in 1969.

52. NEPA called for the formation of a powerful new federal body, the Environmental Protection Agency (EPA), a National Environmental Quality Council (NEQC) to advise the President on environmental matters, and laid the basis for regulations which required the preparation of an Environmental Impact Statement (EIS) for all major projects, including mining developments.

53. The decades of the 1970s and the 1980s saw a prolification of environmental control regulations including the Clean Air Act (1970), the Clean Water Act (1972), regulations to control mining and reclamation of surface coal mines

(1977), the Resource Conservation and Recovery Act (1976), commonly referred to as the Superfund Act.

54. With the exception of the Superfund statute, all of the other laws, as well as a host of other lesser laws, affect the daily operation of mining companies. The Superfund regulations are primarily directed toward the clean up of closed or abandoned mining operations.

55. In addition to these Federal Statutes, most states have enacted similar, though often more stringent, set of regulations pertaining to mining and processing operations. In many cases, the state regulations are tied into their Federal counterparts, thus allowing individual states to take responsibility for implementation and enforcement of the Federal regulations.

56. The United States mineral industries as a whole have become significantly more conscious of the importance of environmental issues over the past decade, a trend sure to continue in the years to come as more new environmental regulations are introduced.

57. Currently most mining companies have an environmental affairs department. Environmental costs are becoming an increasingly significant percentage of operating costs. Closure and reclamation of mining cites are being routinely included in economic evaluation of projects. National organizations retain full-time lobbyists to put forth the view of the mineral industries on environmental legislation, and technical organizations are devoting increased resources to the solution of environmental problems caused by the mineral industries.

58. In parallel with this increased activity on the part of the mineral industries, regulatory agencies at both Federal and State levels have proliferated. These agencies perform a variety of functions including the issuance of permits, monitoring of operations and the verification of compliance.

59. The experience of the United States outlined above where state environmental regulations are tied to Federal ones is of interest to African countries as environmental regulations covering mineral resources development are increasingly becoming international. Thus African countries with mineral resources potential could benefit from knowledge of what other countries are doing to protect their environment in the process of developing their mineral resources.

The Ghana Experience [12]

60. In March 1988 the government of Ghana gave the lead role to the national Environment Protection Council (EPC) to prepare an Environmental Action Plan (EAP) which could help make Ghana's economic development strategy more environmentally sustainable. Six committees were formed as an aid to developing a National Environment Policy (NEP). These covered: mining, industry and hazardous chemicals; land use management; marine and coastal systems; forestry and wildlife; water management; and human settlements.

61. The Committee on Mining, Industry and Hazardous Chemicals began work in July 1988. Detailed consultations in the country were widely undertaken together with the evaluation of experiences of other countries. In November 1988 the Committee reported that existing legislation was generally broad enough to cover environmental control but that there was an absence of specific regulations. The allocation of responsibility was identified as a particularly important topic.

62. The Environmental Protection Council convened a seminar of all experts in late 1988 after the individual committee reports had been received. This seminar identified the lack of provision for environmental education as a serious omission and a consultant was retained to make recommendations on this topic and to act as a general editor for the six reports. He was asked to assign priorities to the various projects put forward by the committees.

63. A National Conference was then convened, to which the edited report was presented. This conference was open to the general public and delegates were also sent from District Assemblies to ensure that the views of the population at large were taken into account. Following the conference a group of consultants from the World Bank and the University of Ghana was asked to undertake an economic appraisal of the various projects proposed and to prepare documentation for identified projects.

64. A final conference is now awaited, for which a report is in preparation. This conference will be targeted specifically at the senior government functionaries who are policy makers. It is envisaged that shortly after the conference an official Environmental Action Plan will be put in place.

65. As the above programme was in hand, the Minerals Commission commenced a study in December 1989 on the effect of mining on the environment. The study, sponsored by the World Bank, aims to formulate guidelines to minimize any adverse effects of increased mining activity on the environment. The study will include a socio-economic assessment of the impact of new mines on the local population.

66. Once the Environmental Action Plan is established, there will be a clear requirement for an Environmental Impact Assessment (EIA) for specified projects. In the interim, the Minerals Commission requires an EIA to be prepared by all new entrants in the mining sector.

67. The manner in which Ghana has been developing a national environmental policy could be a model for other African countries which have not developed similar environmental policies.

The experience of mineral development industries

68. Worldwide, environmental standards are going to be set for the mineral development industries. These standards should be set (according to some industry representatives) by the main mineral development industries in collaboration with governments, investor representatives and relevant intergovernmental and international organizations. Several major mineral development companies in the world seem to recognize that the onus is upon them

to take the lead, anticipate the required environmental standards and initiate programmes consistent with current government initiatives on environment. Some examples to illustrate what is taking place in the industry are given below:

The energy minerals

69. As earlier mentioned, the use of the fuel minerals for energy generation contribute to environmental pollution through acid rain, the greenhouse effect and other disturbances to natural systems which have become international environmental problems in recent years. While various short-term solutions are being applied in several large consuming countries (such as energy conservation; the cleaning of power station gases to reduce acid air gases; technology development and implementation of new technologies in energy production etc), it should be stressed that the contribution of developing Africa towards these international environmental problems is very small indeed, as shown in the previous section on the role of minerals in development.

Metals - The Canadian experience

70. Within the metal industries several recent projects were implemented after detailed environmental conservation and protection measures had been incorporated, using the latest environmental regulatory requirements.[13] However, for some old operations modifications are in the process of introduction as the example below will indicate.

71. During early 1989, the International Nickel Company Limited (INCO), the Canadian firm which is the largest producer of nickel in the Western world informed the Ontario Government that it would spend nearly 500 million Canadian dollars over the next five years to reduce sulphur dioxide emissions from its Sudbury Ontario Smelter Complex. By the end of the five years (1994) sulphur dioxide emissions from the complex will have been reduced by 60% of their previous (1988) levels to comply with requirements of the Ontario Ministry of Environments "Countdown Acid Rain" regulation.[14]

72. The major INCO programme will impact on all stages of the nickel-copper recovery route operated by the company through process modifications. Maximization of sulphur (as pyrrhotite) rejection in the milling operation will be effected to decrease the sulphur input into the Smelter. The milling modifications will also result in savings of manpower, energy and reagent requirements in the milling process.

73. Within the Smelter, existing roasters and reverberating furnaces will be replaced with new oxygen flash smelting furnaces that produce high-strength sulphur dioxide gas suitable for fixation. A large new sulphuric acid plant will be constructed at the Smelter site to fix the high strength gases from the flash smelting furnaces. The INCO project serves as a good example of a mining project which brings an old operation to new environmental standards by process changes which yield economic benefits.

74. The INCO illustration seems to indicate that some other mineral development operations installed in previous years, before environmental concerns were elevated to current public debate, will have to be modified to conform to present and future environmental standards. These improvements might be effected in many countries as environmental standards on many projects with potential adverse effects on the environment become universal requirements. Hence this example could be of interest to some African countries.

Industrial minerals-the European Community (EEC) experience

75. A recent publication on industrial minerals observed that as the European Economic Community (EEC) strives towards the formulation of a unified Europe, the industrial minerals industries of the region should increasingly feel the beneficial effects of a cohesive approach to problem solving, including those related to the environment.[15] The publication expressed the view that a unified Europe (EEC) will have regulatory bodies which will introduce harmonized environmental operational standards for the EEC industrial minerals industries. Accordingly, it is recommended that the EEC (industrial) mineral producers and processors should combine efforts to invoke voluntary, practical and acceptable environmental working standards for their own industries before others, perhaps less knowledgeable, dictate to the industries. The paper acknowledges that many mineral based industries in Europe are having to invest large amounts of money in technology to comply with increasing stringent environmental requirements.

76. Another recent review by a representative of a leading fertilizer company operating plants in several countries in Western Europe observes that environmental control connected with fertilizer production and the impact of fertilizer use upon the environment are subject of great interest currently and in the future.[16] Fertilizer plants often face problems of air pollution, waste water discharge control and waste disposal.

77. In air pollution control the main environmental problems are the sulphur oxide emissions originating from the production of sulphuric acid, nitrogen oxide emissions from the production of nitric acid, fluorine emissions from phosphoric acid and fertilizer plants, and dust emissions from fertilizer plants. The use of the best practicable means in the production of the various acids is a general requirement. In the production of sulphuric acid the so-called double contact technology guarantees minimal emissions of sulphur oxides. In the production of nitric acid the catalytic treatment of emission gases reduces the nitrogen oxide emissions to minimum. The fluorine emissions of sulphuric acid and fertilizer plants have similarly been reduced by the introduction of improved production technology.

78. Waste waters containing phosphorus, nitrogen and heavy metals such as cadmium and mercury constitute environmental problems for which the industry anticipates governments restrictions in the 1990s. The solutions that the industry will then apply will be utilization of phosphates which are less harmful in terms of ecology, the purification of effluents containing undesirable elements, and the further development of production process.

79. Solutions to solid waste disposal are being investigated as gypsum could be utilized economically. Research is similarly underway towards the development of ecologically better fertilizer qualities, the optimum use of fertilizers, and new fertilizing technologies.

80. With regard to health regulations associated with the development and utilization of industrial minerals generally, the paper cited above makes an observation which could be valid for the whole mineral industry. "It is now important for the mineral industry to establish trustworthy relations with occupational hygiene institutes to establish how best the industry could provide the best occupational hygiene conditions for workers".

GENERAL ENVIRONMENTAL CONSIDERATIONS FOR NEW MINERAL DEVELOPMENT PROJECTS

81. It is increasingly becoming common practice for environmental and health impact assessments to be undertaken during the design state for mineral development projects in several countries worldwide. This initiative is supported by many companies, financiers and host governments.

82. The major issues addressed by the environmental impact assessment studies include: land use conflicts; effects of the project on aquatic systems; atmospheric emissions resulting from the project; noise/vibrations which could arise; socio-economic effects of the project; measures to minimize adverse environmental effects and maximize positive effects of project on environment; development of environmental management plan for monitoring project during operation; development of company personnel for environmental management; and assessment of environmental effects upon eventual decommissioning of the project.

83. The disciplines included in the core team of experts for undertaking environmental impact assessments for mineral development projects could comprise such subjects as land use, water use, socio-economics, waste management, hydrogeology, water quality, meteorology, ecology, noise, wildlife etc,. The composition could differ from project to project depending on the mineral and its surroundings. This illustrates how new mineral development plans are increasingly being commenced, taking into account environmental concerns. Hence the requirements of environmental impact assessment (EIA) and environmental management plan (EMP) which require inputs from a whole range of environmental specialists.

84. The development of methodologies for environmental impact assessments that are reasonably accurate will become a future necessity to ensure long-term ecological sustainability in the process of producing goods and services to satisfy the needs of the majority of the people.

85. Environmental education and training, public and technical information and technical assistance, granting the poor access to development resources, political will, etc., are some of the support measures which will enhance environmental protection in the process of mineral development in Africa in the coming years.

CONCLUSIONS AND RECOMMENDATIONS REGARDING ENVIRONMENTAL ASPECTS OF MINERAL RESOURCES DEVELOPMENT IN AFRICA

86. The extreme and widespread poverty which prevails in Africa; the very low consumption of minerals in the region; and the negative effects often associated with the development or non-development of mineral resources, constitute major environmental problems in the continent.

87. Concerted regional and worldwide attack on the social-economic roots of extreme poverty is necessary for sustainable development. This will entail inter-alia, measures to increase the utilization of mineral resources in the production of goods and services required by the African people, and the adoption of mineral development practices which do least harm to the environment.

88. Africa is endowed with a vast variety of mineral resources. However, because mineral resources are unevenly distributed among countries, there is and probably will be a high degree of interdependence among nations in the process of procuring minerals required for economic development. It is thus imperative for the African countries to create the necessary political, economic and technological environments to enhance the development of the mineral resources of the region to meet the needs of the African people.

89. Within the African region there are environmental problems caused by the non-development of indigenous mineral resources as well as those caused by existing mineral industries. Among the environmental concerns caused by the non-development of mineral rescurces include civil strife in some countries; development policies which drive away private initiative in others; and lack of political will at the country levels for bilateral, subregional and regional cooperation in the development process. These negative factors deprive the African people of potential economic and social benefits which could have arisen out of mineral development, worsen the continents living standards, and contribute to the physical deterioration of the environment. The elimination of these negative factors is therefore necessary in order to enhance the living conditions of the Africa people through the development of the continent's mineral resources.

90. Adverse environmental effects on the environment caused by mineral resources development could have local, regional or global dimensions. Moreover, the effects differ in the amount of time they take to become realizable. Furthermore, they differ in severity and reversibility. Local environmental problems (such as solid waste disposal) are those which are confined within the boundaries of a particular country. Regional environmental problems (such as the pollution of a shared river systems) result from biophysical linkages among a group of countries. Global environmental problems (such as the release of gaseous pollutants to the atmosphere) influence the composition of the biosphere and thus affect all countries.

91. Many of the existing large to medium-scale mineral industries of the region are relatively old and therefore may not be operating at safe environmental standards. It might thus be advisable for some of these industries and the host

governments to institute measures to bring these industries to currently acceptable environmental operating conditions. Likewise, new mineral development projects in the region have to incorporate the most up to date environmental conservation and protection measures in order to bring the African industry to world acceptable environmental standards.

92. Additionally, at the present level of mineral development in Africa, the introduction of workable policies, the provision of training and technical assistance, and the provision of physical infrastructure by governments will limit the social and physical environmental degradation caused by small scale mining operations in several countries.

93. For those countries producing minerals known to cause health hazards such as uranium and asbestos, safe working conditions, the introduction of safe means of disposing of waste resulting from mineral development, the ban on the importation of hazardous waste from countries outside Africa, the rehabilitation of mineral development sites etc., should be practised to avoid damage to the environment.

94. The countries of the African region should learn from the experience of other countries on the development and implementation of environmental regulations on the mineral industries. It is increasingly becoming a universal requirement for environmental impact assessments to be undertaken on mineral development projects at the design stages so as to incorporate environmental conservation and protection measures before project commence operation. Similarly, the introduction of new technologies in old mineral development projects to conform to present and future environmental standards is increasingly becoming common in the mineral industries of the world, and would be relevant to some African countries.

95. At the regional environment level, much of the current production of minerals in Africa is not fully processed before export, and the African mineral industries are not integrated with other development activities within the producing countries or in the African region. Thus the minerals produced in the African region are not contributing fully towards alleviating the widespread poverty in the continent. In order to reverse this situation, cooperation by African countries and investors is required so that mineral development in the region can be linked with other national and regional activities intended to produce goods and services for the majority of the African people.

96. At the global level, the contribution of the most of developing Africa towards such environmental problems as acid rain and the greenhouse effect is currently minimal in view of the very small amounts of minerals processed and consumed in the region. However, as energy intensive mineral processing activities expand, and industrialization and mineral consumption increase to meet the needs of a growing population, the contribution of global environmental problems by Africa is likely to increase. Thus the African countries will have to join the world community in devising ways and means of achieving the sustainable development of their mineral resources.

REFERENCES

[1] Eugine P. Pfleider, Population and Minerals, Earth Resources - Voice of America Forum Series, 1973.

[2] World Bank, Environment and Development, Washington, 1975.

[3] Margaret R. Biswas and Asit K. Biswas, The global environment: past, present and future, Resource Policy, Volume II, Number 1, March 1985.

[4] Christopher Flavin and Nicholas Lenssen, Beyond the Petroleum Age: Designing a Solar Economy, Worldwatch Paper 100, December 1990.

[5] United Nations, Energy Statistics Yearbook, 1988.

[6] United Nations, UNCTAD Commodity Yearbook, 1990

[7] Charles Johnson, Ranking countries for mineral exploration, Mining Journal, London, May, 1990.

[8] James F. McDivitt and Gerald Manners, Minerals and Men, The Johns Hopkins University Press, London, 1974.

[9] United Nations, Mineral Processing in Developing Countries, 1984.

[10] Steve Elsworth, A dictionary of the Environment, Paladin Grafton Books, Glasgow 1990.

[11] Mining Journal, London, Volume 314, Number 8059, 23 February 1990.

[12] Mining Journal, London, Volume 315, Number 8085, 24 August 1990.

[13] Andy Shaw, CVRD's Carjas Project, Mining Magazine, August 1990.

[14] ----------, Inco's Sulphur Dioxide Abatement Project, Mining Magazine, November 1989.

[15] ----------, Shaping up to a greener future, Industrial Minerals, Number 254, November 1988.

[16] Hannu Vornamo, Environmental impacts on the fertilizer industry in the 1990s, Industrial Minerals, Number 254, November 1988.

[17] Alvin L. Alm, Ecological Economics, Environmental Science and Technology, Volume 24, Number 12, December 1990.

[18] Johnnie N. Moore and Samuel N. Luena, Hazardous wastes from large-scale metal extraction, Environmental Science and Technology, Volume Number 9, September 1990.

[19] John E. Young, Discarding the Throwaway Society, Worldwatch Paper 101, January 1991.